

**TRENDS IN FINFISH LANDINGS OF SPORT-BOAT ANGLERS  
IN TEXAS MARINE WATERS, MAY 1974 – MAY 2003**

by

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## ABSTRACT

Texas Parks and Wildlife Department personnel have interviewed private-boat anglers at boat-access sites along the Texas coast since May 1974. Party-boat anglers have been interviewed since May 1983. Over 26,200 private-boat and almost 3,300 party-boat anglers were interviewed during the 2002-03 survey year (15 May 2002 to 14 May 2003). Sport-boat (private-boat and party-boat combined) anglers expended an estimated 6.6 million man-h (fishing effort) in 2002-03 to land an estimated 2.1 million fish.

Private-boat anglers in bays and passes accounted for about 78% of the fishing effort and about 67% of the landings in 2002-03. More spotted seatrout (Cynoscion nebulosus) (42%) were landed than any other species. Large numbers of red drum (Sciaenops ocellatus) (12%) and sand seatrout (Cynoscion arenarius) (9%) were also landed.

Party-boat anglers in bays and passes accounted for about 14% of the fishing effort and about 25% of the landings in 2002-03. Spotted seatrout (73%) dominated the landings, followed by red drum (17%).

Private-boat anglers in the Texas Territorial Sea (TTS) accounted for about 3% of the fishing effort and about 3% of the landings in 2002-03. Spotted seatrout (32%), red snapper (Lutjanus campechanus) (17%), king mackerel (Scomberomorus cavalla) (6%), and sand seatrout (6%) were landed most often.

Party-boat anglers in the TTS accounted for less than 1% of the fishing effort and less than 1% of the landings in 2002-03. Spotted seatrout (58%) comprised most of the landings, followed by Spanish mackerel (Scomberomorus maculatus) (10%) and king mackerel (9%).

Private-boat anglers in the United States Exclusive Economic Zone (EEZ) accounted for about 4% of the fishing effort and about 3% of the landings in 2002-03. Red snapper (49%) and king mackerel (12%) were landed most often.

Party-boat anglers in the EEZ accounted for about 1% of the fishing effort and about 1% of the landings in 2002-03. Red snapper (61%) was landed most often, followed by king mackerel (11%) and greater amberjack (Seriola dumerili) (5%).

Most (59%) private-boat anglers resided in counties immediately adjacent to the bay system or gulf area fished in 2002-03. More party-boat anglers resided in non-coastal counties (41%) than in counties immediately adjacent to the bay system or gulf area fished (35%).

Most (70%) bay and pass private-boat and party-boat anglers sought spotted seatrout and/or red drum in 2002-03; 18% sought no particular species. TTS private-boat and party-boat anglers primarily sought king mackerel and/or red snapper (34%) or spotted seatrout and/or red drum (32%); 21% sought no particular species. Most (63%) EEZ private-boat and party-boat anglers sought king mackerel and/or red snapper; 20% sought no particular species.

## INTRODUCTION

Marine sport-boat fishing is an economically and biologically important fishery along the Texas coast. Accurate information collected on an on-going basis is needed to effectively manage this popular fishery.

The first attempt to determine the amount of fish taken annually by sport anglers in Texas coastal waters using personal interviews was conducted in 1957-58 (Beldon Associates 1958). Systematic interviews of a statewide sample of 2,000 households were used to estimate the harvest of spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), and flounder (*Paralichthys* sp.). The study was repeated in 1959-60 for comparison with previous findings (Beldon Associates 1960).

On-site trip-ending interviews of sport-boat anglers were attempted by Simmons (1961) at one site in upper Laguna Madre bay system during August 1959 through July 1960, by Stevens (1963) at one site in San Antonio Bay system during June 1962 through August 1962, and by More (1965) at three sites in Galveston Bay system during June 1963 through June 1964. Each attempt encountered a variety of problems including difficulty estimating overall fishing effort and landings from collected data.

More detailed methods were used by Bowman et al. (1976) in an attempt to estimate total fish yield from the Corpus Christi Bay area. On-site trip-ending interviews of sport anglers were conducted at multiple boat-access and shore-based sites during June through August 1974.

Based in part on these early attempts, Heffernan et al. (1976) and Breuer et al. (1977) initiated the survey that is the subject of this report. On-site trip-ending interviews of sport anglers were conducted at multiple boat-ramp sites in the Galveston, San Antonio, Aransas, and upper Laguna Madre bay systems during September 1974 through August 1975; and in the Sabine Lake, Matagorda, Corpus Christi, and lower Laguna Madre bay systems during September 1975 through August 1976 (Heffernan and Green 1977).

Several aspects of the survey were modified during the next eight years to enhance survey efficiency and to increase accuracy and precision of collected data (Green et al. 1978; McEachron 1980a, 1980b; McEachron and Green 1982, 1983, 1984; Osburn and Ferguson 1985, 1986). Osburn and Osborn (1991) described these modifications and explained efforts to ensure comparability of data collected during these years. The survey proceeded with few changes during subsequent years (Osburn and Ferguson 1987; Osburn et al. 1988; Maddux et al. 1989; Green et al. 1991a, 1991b; Campbell et al. 1991; Weixelman et al. 1992; Warren et al. 1994; Green et al. 2002).

The primary objectives of this study were to estimate daytime annual fishing pressure (effort in man-hours), landings (number of fish harvested), catch rates (harvest per unit effort as an indicator of resource availability or fishing success), species compositions, and size compositions (mean lengths and mean weights of fish harvested) for sport-boat anglers on trips lasting 12 h or less in Texas marine waters. The secondary objectives were to summarize the residential origin, species sought, and trip satisfaction of these sport-boat anglers and to assemble

supporting information to aid in interpretation of study results. The tertiary objectives were to estimate daytime annual fishing pressure, landings, and catch rates for bay and pass private-boat anglers on trips lasting more than 12 h, and to summarize their residential origin.

For sport-boat trips lasting 12 h or less, this report includes previously published estimates for the 1974-76 through 1997-98 survey years (Green et al. 2002), first-time publication of estimates for the 1998-99 through 2002-03 survey years, and first-time publication of species sought and trip satisfaction data for the 1989-90 through 2002-03 survey years. This report also includes first-time publication of supplementary estimates from bay and pass private-boat trips lasting more than 12 h for the 1983-84 through 2002-03 survey years.

## MATERIALS AND METHODS

Procedures used to collect data summarized in this report changed over time. A developmental process occurred in which changes and refinements were incorporated to improve the survey. Major changes to the survey on 15 May 1983 remained in affect through 14 May 2003. Refinements were added to the survey on 15 May 1992, and procedures detailed in this report apply to this date and beyond.

The primary focus of the Texas Marine Sport-Harvest Monitoring Program was private-boat bay and pass fishing. Private-boat gulf fishing, party-boat bay and pass fishing, and party-boat gulf fishing also were surveyed.

### Survey Attributes

#### Target Population

The target population for the survey consisted of sport-boat angling parties with trip lengths of 12 h or less that ended their fishing trips from 1000 to 1800 hours at inventoried boat-access sites. These angling parties were divided into two groups: private-boat parties (i.e., those using privately-owned and rental boats, as well as those fishing in tournaments) and party-boat parties (i.e., those using a professional fishing guide and had ten or fewer people).

#### Spatial Dimensions

Texas marine waters were divided into two primary areas for the survey: bay and pass (i.e., marine waters shoreward of barrier islands, including the openings or passes that connect bays with the Gulf of Mexico) and gulf (i.e., Gulf of Mexico waters). Pass areas were defined as extending 1.9 km gulfward from the gulfward end of the pass.

Bay and pass areas were divided geographically into eight bay systems: Sabine Lake, Galveston Bay, Matagorda Bay (including East Matagorda Bay), San Antonio Bay, Aransas Bay, Corpus Christi Bay, upper Laguna Madre, and lower Laguna Madre (Figure 1). Except for 1975-76, Sabine Lake was not included in the survey until 15 May 1987.

Gulf areas were divided into five geographic areas based on proximity of access. These included gulf waters off Sabine Lake; Galveston Bay; Matagorda and San Antonio Bays; Aransas and Corpus Christi Bays, and upper Laguna Madre; and lower Laguna Madre. Each of these areas was further divided into two areas based on governmental jurisdiction: Texas Territorial Sea (TTS) (i.e., Gulf of Mexico waters from the surf line to 16.7 km offshore, excluding the 1.9-km area around the gulfward end of passes) and United States Exclusive Economic Zone (EEZ) (i.e., Gulf of Mexico waters off Texas beyond 16.7 km offshore).

### Temporal Dimensions

Surveys were conducted year-round. A survey year extended from 15 May of one year to 14 May of next year. Each survey year was divided into a high-use season and a low-use season based on distribution of fishing effort. The high-use season extended from 15 May to 20 November of one year. The low-use season extended from 21 November of one year to 14 May of the next year. Each season was further divided into weekend days (Saturday and Sunday) and weekdays (Monday through Friday).

### Number of Surveys

The targeted level of precision for the survey from 15 May 1983 forward was based on survey data collected prior to that date. Sample sizes were set to detect a 50% difference in fishing pressure and landings estimates, 80% of the time, at the 95% confidence level. This level of sampling was expected to produce coefficients of variation around 10% for coastwide fishing pressure and landings.

Since 15 May 1983, 1,014 routine surveys were scheduled annually to estimate bay and pass fishing pressure and landings. In high-use season, 26 weekend and 46 weekday surveys were scheduled for Sabine Lake and San Antonio bay systems, and 31 weekend and 66 weekday surveys were scheduled for the other six bay systems. In low-use season, 12 weekend and 24 weekday surveys were scheduled for all bay systems.

About 36 "gulf-only" surveys were scheduled each high-use season to supplement routine surveys for estimation of gulf fishing pressure and landings. These surveys were initiated on 15 May 1992, and their distribution was variable between weekend days and weekdays. During gulf-only surveys, only sport-boat gulf fishing parties were interviewed in full; other boating parties were given abbreviated interviews. Gulf-only surveys were conducted only at sites known to have sport-boat gulf fishing activity.

### Target Species

All landed species were enumerated during surveys. Target species for estimation of landings and catch rates were selected for their historical, current, or anticipated importance, and differed between bay and pass, and gulf areas.

Bay and pass estimates were determined for ten species or species groups: Atlantic croaker (*Micropogonias undulatus*), black drum, gafftopsail catfish (*Bagre marinus*), red drum,



sand seatrout (Cynoscion arenarius), sheepshead (Archosargus probatocephalus), southern flounder (Paralichthys lethostigma), spotted seatrout, "other" species (all remaining species), and all species combined.

Gulf estimates were determined for twenty species or species groups: Atlantic croaker, Atlantic sharpnose shark (Rhizoprionodon terraenovae), Atlantic spadefish (Chaetodipterus faber), black drum, blacktip shark (Carcharhinus limbatus), cobia (Rachycentron canadum), dolphin (Coryphaena hippurus), gray triggerfish (Balistes capriscus), greater amberjack (Seriola dumerili), king mackerel (Scomberomorus cavalla), lane snapper (Lutjanus synagris), little tunny (Euthynnus alletteratus), red drum, red snapper (Lutjanus campechanus), sand seatrout, Spanish mackerel (Scomberomorus maculatus), spotted seatrout, vermilion snapper (Rhomboplites aurorubens), "other" species (all remaining species), and all species combined.

### Survey Site Inventory

The sampling frame consisted of inventoried boat-access sites. Sites were uniquely numbered in each bay system, and included boat ramps and wet-slip sites accessible to the general public and survey personnel. Boating facilities at private residences were not included.

The site inventory was updated biannually to reflect opening of new sites, closing of old sites, and reopening of closed sites. The numbering system for sites was revised effective 15 May 1983 when wet-slip sites (Spiller 1987) were added and site numbers were reassigned. There were 273 active sites in both the 2002 high-use and 2002-03 low-use seasons (Appendix A.1). Of these, 41 were considered active gulf sites in the 2002 high-use season and 19 in the 2002-03 low-use season.

### Survey Site Roving Counts

Roving counts of inventoried boat-access sites were conducted to determine the number of boating parties using each site. Since 15 May 1983, 128 roving counts were conducted annually.

Roving counts were conducted in each bay system by driving from site to site and counting empty boat trailers and empty wet slips. Wet-slip counts were adjusted based on number of non-rented slips at or near time of rove. These counts occurred during a 4.5-h period from 0800 to 1230 hours on weekends and weekdays during high-use and low-use seasons.

Roving counts were conducted on "good-weather" days to maximize counts and to obtain a better definition of differences among sites. In high-use season, a good-weather day was when Small Craft Advisories were not in effect. In low-use season, a good-weather day was determined based on a nomograph (Spiller et al. 1988) consisting of air temperature, wind speed, and precipitation measured at 0800 hours on day of rove.

Ten roving counts were done in each bay system during high-use season. One weekend rove and one weekday rove were conducted during each of the following five periods: 15 May-30 June, 1-31 July, 1-31 August, 1-30 September, and 1 October-20 November. For weekend

roves, two must have been conducted on Saturdays and two must have been conducted on Sundays.

Six roving counts were done in each bay system during low-use season. One weekend rove and one weekday rove were conducted during each of the following three periods: 21 November-31 January, 1 February-31 March, and 1 April-14 May. For weekend roves, one must have been conducted on Saturday and one must have been conducted on Sunday.

### Survey Site Relative Fishing Pressures

#### Bays and Passes

Prior to each season, two relative fishing pressure files were created for each bay system, one for weekends and one for weekdays. This resulted in 32 bay and pass pressure files coastwide each year. Pressure files were used in the selection of boat-access sites to be surveyed.

For each season, roving counts for each site from the previous three years were averaged for each day type; counts from the most recent year were weighted 50% and counts from the other two years were weighted 25% each. For each day type, the average count at a given site was adjusted for target-area, bay and pass, private-boat fishing activity and for boat-trailer parking location based on survey data collected at that site during the previous three years. For sites in each bay system with less than ten interviews during the previous three years, a single generic adjustment was created for each day type by pooling the survey data from all such sites in the bay system. Adjustment for boat-trailer parking location accounted for trip-ending parties at each site that would not have had an empty boat trailer or empty wet slip available for counting during a rove.

For each day type in each season, the adjusted average count for each site was divided by the sum of the adjusted average counts from all sites in that bay system to produce a relative fishing pressure value for each site. This value represented the proportion of the total bay system fishing pressure occurring at that site.

#### Gulf Areas

Prior to each high-use season, weekend and weekday gulf pressure files were created for each of the five gulf areas. Ten separate pressure files were produced. These were used in the selection of boat-access sites for supplemental gulf-only surveys.

Roving counts were averaged and adjusted in the same manner as described for bays and passes with the following exceptions. TTS and EEZ interview data from routine and gulf-only surveys were pooled to adjust roving counts for each of the five gulf areas. Since there were much fewer gulf than bay and pass interviews, more than three previous years of interview data were used to adjust roving counts for target-area gulf fishing (six previous years for the gulf off Galveston Bay and four previous years for the gulf off the other four areas). Many of the inventoried boat-access sites had little or no gulf fishing activity. These sites were eliminated

from the gulf pressure files based on four threshold values applied to adjusted rove counts. If the adjusted rove count fell below 1.0 on high-use weekends, 0.3 on high-use weekdays, 0.2 on low-use weekends, or 0.1 on low-use weekdays, then the site was dropped from the gulf pressure file for that season and day-type combination. Adjusted rove counts from dropped sites were pooled and retained for each pressure file.

### Survey Site Selection and Survey Scheduling

Prior to each season a sampling schedule was generated for each day type in each bay system based on the relative fishing pressure files. The selection process was divided into 30-day intervals to ensure even distribution of surveys throughout the season.

Proportional random sampling (with replacement) was used to select survey sites for each bay system. Sites were selected in proportion to their relative fishing pressure values and thus had an unequal chance of being selected (e.g., a site with 5% of a bay system's fishing pressure would receive about 5% of the scheduled surveys). To reduce the number of survey days with no interviews conducted, a site was not included for selection if its adjusted rove count was below 3.0 on weekends or 1.0 on weekdays (no rounding up), or if its ideal number of surveys (product of total number surveys to be conducted by day type and relative pressure of site by day type) did not round up to or exceed one survey. The most inclusive of the two thresholds was applied.

Semi-random sampling (without replacement) was used to select a set number of weekend and weekday survey dates for each 30-day interval. An effort was made to balance the number of surveys among days of the week within each day type. These measures allowed sampling effort to be evenly distributed across seasons and day types. Weekly workload constraints were also considered.

To reduce the number of surveys conducted at "crossover" sites, the bay and pass schedule was adjusted to maximize the number of "double" surveys conducted at these sites. A site located in one bay system was designated as a crossover site for an adjacent bay system if adjacent-bay-system fishing activity originating from that site represented at least 1% of the adjacent bay system's fishing activity. Crossover sites occurred in boundary areas between Matagorda and San Antonio Bay systems; San Antonio and Aransas Bay systems; Aransas and Corpus Christi Bay systems; and Corpus Christi and upper Laguna Madre bay systems (Appendix A.1). When a double survey was conducted, the survey counted as a survey for both bay systems. Double surveys reduced manpower needs and the likelihood of over-burdening anglers at crossover sites. From May 1983 to May 1992, the list of crossover sites was not modified. Beginning in May 1992 the list of crossover sites was evaluated annually based on the 1% criterion described above.

An effort was made to evenly distribute frequently surveyed sites across each season for each day type. This was important because fishing pressure and landings were distributed unevenly across seasons.

After the high-use season bay and pass schedule was drawn and examined for representation by sites included in the gulf pressure files, gulf-only surveys were added to the survey schedule in proportion to the gulf pressure file. Gulf-only surveys were not conducted in low-use season due to the relatively small amount of gulf fishing pressure at that time of the year.

## Survey Procedures

### Overview

The purpose of conducting surveys was threefold. First, they were used to collect fishing effort (man-hours based on trip length and number of anglers in party) and harvest (does not include fish caught and released) data for estimation of fishing pressure, landings, and catch rates. Second, they were used to collect data on boating-activity type, boating-activity location, and boat-trailer location for adjustment of roving counts. Third, they were used to collect other data for other purposes (e.g., gear used, bait used, angler residential origin, species sought, and trip satisfaction). Weixelman and Chai (1991) and Morris et al. (1999) examined bait-use data. Green et al. (1991a, 1991b, 1991c) summarized species sought and trip satisfaction data.

When a site was surveyed, all trip-ending boat parties intercepted between 1000 and 1800 hours were interviewed. Relatively few interviews were "missed" because multiple personnel were assigned to busy sites. Based on examination of previously collected data (Spiller et al. 1988), surveys were cancelled in the low-use season on "bad-weather" days. A bad-weather day was determined based on a nomograph consisting of air temperature, wind speed, and precipitation observed at 0900 hours. Also based on examination of previously collected data (Weixelman and Green 1984, Osburn and Weixelman 1989), surveys were terminated early if no angling activity interviews were conducted by pre-determined times: 1300 hours on high-use season weekends; 1400 hours on high-use season weekdays and low-use season weekends; and 1600 hours on low-use season weekdays.

The primary equipment used for conducting surveys included a 1-meter measuring board, a fish identification book (primarily Hoese and Moore 1977, 1998), and standard data sheets. Except for reducing the number of lines per page from fifteen to ten on 1 July 1995, the same data-sheet format has been used since 15 May 1983.

### Routine Surveys

Data elements collected from angling parties included boat identification number; time when interview was conducted; trip length to nearest 0.5 h (not fishing time); type of fishing activity (private-boat or party-boat); number of anglers and residential origin of each (non-fishing party members not included); location where most of the harvested fish were caught or location where most fishing effort occurred if no fish were harvested; gear and bait used to catch harvested fish or gear and bait used most if no fish were harvested; location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat); species sought and trip satisfaction level for one randomly selected party member; number of each

species landed (if any); and total lengths to nearest millimeter for up to six randomly selected specimens of each species landed (if any).

Data elements collected from non-angling parties included boat identification number; time when interview was conducted; trip length to nearest 0.5 h; type of boating activity; number of people and residential origin of each; location where most of the boating activity occurred; and location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat).

### Gulf-only Surveys

Data elements collected from gulf angling parties during gulf-only surveys were the same as those collected during routine surveys.

Data elements collected from other boating parties were limited to boat identification number; time when interview was conducted; type of boating activity; location where most of the boating activity occurred; and location where trailer was parked during trip (or if wet-slip used, then whether wet-slip was rented for the boat).

### Survey Operations Manual and Quality Control

Survey and roving-count procedures were contained in a detailed operations manual (Texas Marine Sport-Harvest Monitoring Program Operations Manual) that was updated annually. The manual also included data encoding lists, weekend and weekday nomographs for low-use season, and a history of procedure changes.

A quality control program for surveys and roving counts was initiated in October 1986 to monitor compliance with established procedures. The program included assigned observers who periodically visited personnel conducting surveys and roving counts. Refinements to the program were made in May 1990 and January 1994. Since January 1994, quality control visits were conducted monthly for surveys and annually for roving counts in each bay system using detailed report forms.

### Data Processing

Survey and roving count data sheets were edited and submitted for computer keying. Data were keyed into a temporary database and subjected to computer programmed error checks. Keyed data were printed with potential errors flagged for manual line-by-line edit against original data sheets. Needed corrections were made and data were transferred to a permanent database for later access as needed.

### Calculation of Fishing Pressure and Harvest Estimates

Methods used to calculate fishing pressure (effort) and harvest estimates from data collected prior to 15 May 1992 were described by Osburn and Osborn (1991) and Warren et al. (1994). These methods were followed in this study with several exceptions.

In the early 1990's, computer programming for creation of relative fishing pressure files and for calculation of estimates was converted from PL1 to SAS® (SAS Institute Inc., Cary, North Carolina). During this conversion several changes were made. The most important change eliminated the use of non-target-area fishing activity in determination of relative pressure values and in summary of daily fishing effort and landings for each site. This change, applied to data collected after 14 May 1992, increased the accuracy of pressure files and estimates for each bay system, but jeopardized strict comparison with previously calculated estimates. To achieve comparability, pressure files and estimates were recalculated for the 1983-84 through 1991-92 survey years. Recalculation was preceded by an extensive effort to detect and correct miscoded data in the database. Because of inconsistencies in sampling procedures prior to 15 May 1983, pressure files and estimates were not recalculated for the 1974-76 through 1982-83 survey years.

Another change involved pressure file application. Previous methodology used the same pressure file to select survey sites during schedule preparation and to expand observed fishing effort and landings during estimate calculation. Updated methodology used a preliminary pressure file for site selection (as previously described) and a final pressure file for expansion. The final pressure file incorporated target-period roving count and survey data to make it more reflective of target-period conditions. Roving counts from the target-period and the previous two years were averaged for each day type; counts from the target-period were weighted 50% and counts from the other two years were weighted 25% each. For bays and passes, survey data from the target-period and the previous two years were used to adjust the average rove counts. For the gulf, survey data from the target-period and the previous three (gulf off all areas except Galveston) or five (gulf off Galveston) years were used to adjust the average rove counts. These changes also increased the accuracy of pressure files and estimates for each bay system and gulf area.

For each bay system and gulf area, survey data were summarized first by interview, then by site for each day. Fishing effort in man-hours was determined as the product of number of people fishing and trip length. Harvested fish were tallied by species. Site summaries for each day were adjusted for missed interviews and daylight hours not surveyed, then expanded based on relative pressure values. Adjusted and expanded site summaries were averaged by bay system (or TTS or EEZ gulf area), season, and day type. Mean daily estimates were further expanded to represent seasonal estimates for each day type by multiplying them by the total number of days in each season and day-type combination. Seasonal estimates were determined by combining day-type estimates. Annual estimates were determined by combining season estimates. See Appendix A.2 for more details on calculation of fishing pressure, landings, catch rates, and associated standard error estimates.

#### Calculation of Mean Lengths and Mean Weights

Prior to 15 May 1983, landings for each fishing party were counted and weighed en masse by species. Beginning 15 May 1983, landings were measured for total length rather than weighed. Total length was measured by compressing the caudal fin lobes dorsoventrally to obtain the maximum possible total length. Standard or fork length measurements were taken when total length measurements were not available.

Mean lengths prior to 15 May 1983 were generated from weight-to-length conversions. Mean weights after 14 May 1983 were generated from length-to-weight conversions. Standard and fork lengths were converted to total lengths with length-to-length conversions. See Appendix A.3 for details on length conversions and Appendix A.4 for details on mean length and mean weight calculations.

### Calculation of Other Statistics

Other statistics calculated from survey data included number of days surveyed, number of interviews conducted, number of anglers interviewed, mean fishing party size, mean trip length, composition of "other" species, angler residential origin, species sought, and trip satisfaction. These statistics were based on direct summary of unadjusted and unexpanded interview data. See Appendix A.5 for details on determination of angler residential origin and Appendix A.6 for details on determination of species sought and trip satisfaction.

### Calculation of Estimates for Bay and Pass Private-boat Trips Lasting More Than 12 Hours

Although most sport-boat fishing trips encountered with this survey lasted 12 h or less, a considerable number of trips have been intercepted that lasted more than 12 h. These longer trips were undertaken primarily by bay and pass private-boat anglers in the upper Laguna Madre bay system. Trips lasting more than 12 h often included non-fishing activity, such as spending the night in cabins accessible only by boat. Based on a study by Spiller et al. (2000), trip lengths for trips lasting more than 12 h were adjusted downward to eliminate time spent on non-fishing activities.

Interviews of bay and pass private-boat fishing parties on trips lasting more than 12 h were conducted in the same manner as fishing parties on trips lasting 12 h or less. Using methods described above, separate relative pressure files were created for bay and pass private-boat fishing trips lasting more than 12 h. These were used to calculate fishing pressure (effort) and harvest estimates.

## RESULTS

Findings included in this report date back to 1974. In the sections below, results are presented primarily in terms of the most recent ten years (1993-2003) and the most recent year (2002-03). Except where noted, results presented below are for daily trips lasting 12 h or less.

All trip-ending parties encountered during surveys were enumerated in some manner based on their boating activity type. Most (78%) of the 16,844 interviews conducted during 2002-03 involved sport-boat fishing (Table 1).

## Coastwide Overview

The vast majority of annual coastwide sport-boat fishing pressure and landings occurred in bays and passes during 1983-2003 (Table 2; Figure 2). Pressure and landings were slightly greater in the EEZ than the TTS in most years. About 6.6 million man-h were expended to land about 2.1 million fish in 2002-03. Private-boat fishing accounted for about 85% of the annual coastwide sport-boat fishing pressure and about 73% of the landings in 2002-03.

During the 2002-03 survey year, 11,477 marine sport-boat angling parties on trips lasting 12 h or less were interviewed. These included 9,793 private-boat (Appendix B, Table B.1) and 816 party-boat (Appendix C, Table C.1) parties from bays and passes; 429 private-boat (Appendix D, Table D.1) and 15 party-boat (Appendix E, Table E.1) parties from the TTS; and 400 private-boat (Appendix F, Table F.1) and 24 party-boat (Appendix G, Table G.1) parties from the EEZ. An additional 414 private-boat angling parties from bay and pass trips lasting more than 12 h were interviewed during 2002-03 (Appendix H, Table H.1).

## Bays and Passes

### Private-boat Fishing

Private-boat fishing in bays and passes accounted for about 81% of the annual coastwide fishing pressure and about 76% of the landings during 1993-2003 (Table 2). During 1993-2003, an average of 5.4 million man-h were expended annually to land an average of 1.8 million fishes. In 2002-03, about 5.1 million man-h were expended to land about 1.4 million fishes (Figure 3; Appendix B, Tables B.2, B.3). Annual bay and pass private-boat fishing pressure and landings were on average at least three times greater in Galveston Bay system than in any of the other bay systems during 1993-2003 (Figure 4).

More spotted seatrout (36%) were landed annually from bays and passes by private-boat anglers than any other species during 1993-2003 (Figure 5). Large numbers of sand seatrout, Atlantic croaker, and red drum also were landed. Atlantic croaker, black drum, sand seatrout, southern flounder, and spotted seatrout were landed most often from Galveston Bay system; gafftopsail catfish from Matagorda Bay system; red drum from Aransas Bay system; and sheepshead from Corpus Christi Bay system (Figures 6, 7). Landings of black drum, red drum, and spotted seatrout were spread more evenly among bay systems than other species. Fifty-six additional species were landed from bays and passes by private-boat anglers in 2002-03 (Appendix B, Table B.7).

Trends in annual coastwide private-boat landings, catch rates, mean lengths, and mean weights during 1974-2003 are illustrated for the eight bay and pass target species in Figures 8-15.

After declining and being quite variable in early years, annual coastwide private-boat spotted seatrout landings and catch rates from bays and passes stabilized to around 0.6 million fish and 0.12 fish/man-h during 1992-2003 (Figure 8; Appendix B, Tables B.3, B.4). Mean



lengths and mean weights increased steadily until leveling off in later years (Figure 8). In 2002-03, spotted seatrout averaged 438 mm and 0.83 kg coastwide (Appendix B, Tables B.5, B.6).

Annual coastwide private-boat red drum landings increased from 94 thousand fish in 1990-91 to 241 thousand fish in 1993-94, but fell to 161 thousand fish in 2002-03 (Figure 11). Mean lengths and mean weights increased steadily until leveling off in recent years. In 2002-03, red drum averaged 597 mm and 2.42 kg coastwide (Appendix B, Tables B.5, B.6).

### Party-boat Fishing

Party-boat fishing in bays and passes accounted for about 11% of the annual coastwide fishing pressure and about 17% of the landings during 1993-2003 (Table 2). During 1993-2003, an average of 0.7 million man-h were expended annually to land an average of 0.4 million fishes. Fishing pressure and landings increased steadily and reached all-time highs in 2000-01 of 1.1 million man-h and 0.6 million fishes (Figure 16; Appendix C, Tables C.2, C.3). About 73% of the average annual bay and pass party-boat fishing pressure and landings during 1993-2003 occurred in the four bay systems of the lower half of the coast (Figure 17).

Spotted seatrout (76%) dominated annual coastwide party-boat landings from bays and passes during 1993-2003 (Figure 18). Red drum (14%) also was landed in large numbers. Twenty-one additional species were landed from bays and passes by party-boat anglers in 2002-03 (Appendix C, Tables C.3, C.7).

Trends in annual coastwide bay and pass party-boat landings, catch rates, mean lengths, and mean weights for spotted seatrout and red drum during 1974-2003 are illustrated in Figures 19-20.

Annual coastwide party-boat landings of spotted seatrout from bays and passes increased dramatically since 1990-91 and reached an all-time high of about 438 thousand fish in 2000-01 (Figure 19). The catch rate averaged 0.41 fish/man-h over the last eleven years (Appendix C, Table C.4). Mean lengths and mean weights increased slightly over the years. In 2002-03, spotted seatrout averaged 448 mm and 0.90 kg coastwide (Appendix C, Tables C.5, C.6).

Annual coastwide party-boat landings of red drum from bays and passes increased over the years and reached an all-time high of about 86 thousand fish in 2002-03 (Figure 20). Catch rates declined since 1993-94 to a near all-time low of 0.06 fish/man-h in 2001-02, but rose to 0.09 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years with coastwide estimates of 610 mm and 2.54 kg in 2002-03 (Appendix C, Tables C.5, C.6).

## Texas Territorial Sea

### Private-boat Fishing

Private-boat fishing in the TTS accounted for about 3% of the annual coastwide fishing pressure and about 3% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 231 thousand man-h were expended annually to land an average of 71 thousand fishes.

Fishing pressure and landings reached all-time highs of 304 thousand man-h and 100 thousand fishes in 1996-97 (Figure 21; Appendix D, Tables D.2, D.3). In 2002-03, about 216 thousand man-h were expended to land about 61 thousand fishes. Average annual TTS private-boat fishing pressure (44%) and landings (39%) were greatest offshore of the Galveston Bay system during 1993-2003 (Figure 22).

Spotted seatrout (27%), red snapper (17%), king mackerel (11%), and sand seatrout (9%) were the most often landed species from TTS private boats during 1993-2003 (Figure 23). Forty additional species were landed from the TTS by private-boat anglers in 2002-03 (Appendix D, Tables D.3, D.7).

Trends in annual coastwide TTS private-boat landings, catch rates, mean lengths, and mean weights during 1982-2003 are illustrated for red snapper and king mackerel in Figures 24-25.

Annual coastwide private-boat landings of red snapper from the TTS increased dramatically since 1991-92 and reached an all-time high of about 19 thousand fish in 1994-95 and 1995-96 (Figure 24). Landings declined to about 10 thousand fish in 2002-03. Catch rates were quite variable with 0.05 fish/man-h estimated for 2002-03 (Appendix D, Table D.4). Mean lengths and mean weights increased steadily over the years to all-time highs of 494 mm and 1.90 kg during 1998-99, but fell to 473 mm and 1.62 kg during 2002-03 (Appendix D, Tables D.5, D.6).

Annual coastwide private-boat landings of king mackerel from the TTS steadily declined from an all-time high of about 14 thousand fish in 1996-97 to about 4 thousand fish in 2002-03 (Figure 25). Catch rates also declined in recent years to a low of 0.2 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years. King mackerel averaged 971 mm and 5.08 kg in 2002-03 (Appendix D, Tables D.5, D.6).

#### Party-boat Fishing

Party-boat fishing in the TTS accounted for less than 1% of the annual coastwide fishing pressure and less than 1% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 18 thousand man-h were expended annually to land an average of 8 thousand fishes. In 2002-03, about 15 thousand man-h were expended to land about 9 thousand fishes (Appendix E, Tables E.2, E.3). Catch rates, mean lengths, and mean weights are presented in Appendix E, Tables E.4, E.5, and E.6.

Spotted seatrout (36%), red snapper (31%), and king mackerel (14%) were the most often landed species from TTS party boats during 1993-2003 (Figure 18). Nine additional species were landed from the TTS by party-boat anglers in 2002-03 (Appendix E, Tables E.3, E.7).

## United States Exclusive Economic Zone

### Private-boat Fishing

Private-boat fishing in the EEZ accounted for about 4% of the annual coastwide fishing pressure and about 4% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 277 thousand man-h were expended annually to land an average of 86 thousand fishes. Fishing pressure increased from a low of 132 thousand man-h in 1993-94 to an all-time high of about 353 thousand man-h in 1996-97, but decreased thereafter (Figure 26). Landings followed a similar pattern peaking at about 135 thousand fish in 1996-97. In 2002-03, about 236 thousand man-h were expended to land about 63 thousand fishes (Appendix F, Tables F.2, F.3). Average annual EEZ private-boat fishing pressure (50%) and landings (44%) were greatest offshore of the Galveston Bay system during 1993-2003 (Figure 27).

Red snapper (52%), king mackerel (13%), dolphin (6%), and gray triggerfish (4%) were the most often landed species from EEZ private boats during 1993-2003 (Figure 23). Forty-five additional species were landed from the EEZ by private-boat anglers in 2002-03 (Appendix F, Tables F.3, F.7).

Annual coastwide private-boat landings of red snapper from the EEZ increased from a low of 16 thousand fish in 1989-90 to 79 thousand fish in 1996-97 (Figure 28). Landings declined to 31 thousand fish in 2002-03. The coastwide catch rate was 0.13 fish/man-h in 2002-03 (Appendix F, Table F.4). Mean lengths and mean weights increased steadily over the years to all-time highs of 479 mm and 1.88 kg during 1998-99, but fell to 476 mm and 1.68 kg in 2002-03 (Appendix F, Tables F.5, F.6).

Annual coastwide private-boat landings of king mackerel from the EEZ increased from 6 thousand fish in 1993-94 to 18 thousand fish in 1997-98, then fell to 8 thousand fish in 2002-03 (Figure 29). The coastwide catch rate was 0.03 fish/man-h in 2002-03. Mean lengths and mean weights changed little over the years. King mackerel averaged 931 mm and 4.41 kg in 2002-03 (Appendix F, Tables F.5, F.6).

### Party-boat Fishing

Party-boat fishing in the EEZ accounted for less than 1% of the annual coastwide fishing pressure and less than 1% of landings during 1993-2003 (Table 2). During 1993-2003, an average of 35 thousand man-h were expended annually to land an average of 16 thousand fishes. In 2002-03, about 40 thousand man-h were expended to land about 26 thousand fishes (Appendix G, Tables G.2, G.3). Catch rates, mean lengths, and mean weights are presented in Appendix G, Tables G.4, G.5, and G.6.

Red snapper (45%) and king mackerel (23%) were the most often landed species from EEZ party boats during 1993-2003 (Figure 18). Twenty-two additional species were landed from the EEZ by party-boat anglers in 2002-03 (Appendix G, Tables G.3, G.7).

### Angler Residential Origin

The majority (62%) of annual coastwide bay and pass private-boat anglers resided in coastal counties adjacent to the bay system fished during 1993-2003 (Figure 30; Appendix B, Table B.8). Among bay systems, Galveston (94%) and Sabine Lake (90%) had the greatest proportions of bay and pass private-boat anglers from coastal counties adjacent to the bay system fished; San Antonio (29%) had the greatest proportion from coastal counties not adjacent to the bay system fished; Aransas had the greatest proportion from non-coastal counties (52%), and Corpus Christi had the greatest proportion from other states and countries (11%) (Figure 31).

The residential origin of most annual coastwide bay and pass party-boat anglers during 1993-2003 was evenly split between coastal counties adjacent to the bay system fished (38%) and non-coastal counties (38%) (Figure 32; Appendix C, Table C.8). Among bay systems, Galveston had the greatest proportion of bay and pass party-boat anglers from adjacent coastal counties (81%); Matagorda had the greatest proportion from coastal counties not adjacent to the bay system fished (46%); Corpus Christi had the greatest proportion from non-coastal counties (58%); and Sabine Lake had the greatest proportion from other states and countries (11%) (Figure 33).

The majority of annual coastwide TTS (56%) and EEZ (64%) private-boat anglers resided in coastal counties adjacent to the area fished during 1993-2003 (Figure 30; Appendix D, Table D.8; Appendix F, Table F.8). Among gulf areas, Sabine Lake and Galveston had the greatest proportions of TTS and EEZ private-boat anglers from coastal counties adjacent to the area fished (about 90%); Matagorda had the greatest proportion from coastal counties not adjacent to the bay system fished (about 24%); and Corpus Christi had the greatest proportion from non-coastal counties (about 54%) (Figure 34).

The residential origin of most annual coastwide TTS and EEZ party-boat anglers during 1993-2003 was almost evenly split between coastal counties adjacent to the gulf area fished (about 45%) and non-coastal counties (about 40%) (Figure 32; Appendix E, Table E.8; Appendix G, Table G.8). There were differences among gulf areas, but these were less defined due to the small number of anglers encountered (Figure 35).

### Species Sought by Anglers

Bay and pass private-boat anglers primarily sought spotted seatrout (17%), red drum (13%), flounder (3%), a combination of spotted seatrout and red drum (38%), or a combination of spotted seatrout, red drum, and flounder (4%) during 1993-2003 (Figure 36; Appendix B, Table B.9). Many anglers sought no particular species (19%).

Bay and pass party-boat anglers primarily sought spotted seatrout (25%), red drum (14%), or a combination of spotted seatrout and red drum (46%) during 1993-2003 (Figure 36; Appendix C, Table C.9). About 11% of anglers sought no particular species.

TTS private-boat anglers primarily sought king mackerel (34%), spotted seatrout (14%), red snapper (8%), red drum (2%), a combination of spotted seatrout and red drum (9%), or a

combination of king mackerel and red snapper (3%) during 1993-2003 (Figure 37; Appendix D, Table D.9). Many anglers sought no particular species (20%).

TTS party-boat anglers primarily sought spotted seatrout (19%), king mackerel (13%), tarpon (12%), red snapper (5%), a combination of spotted seatrout and red drum (21%), or a combination of king mackerel and red snapper (6%) during 1993-2003 (Figure 37; Appendix E, Table E.9). About 17% of anglers sought no particular species.

EEZ private-boat anglers primarily sought red snapper (27%), king mackerel (25%), or a combination of red snapper and king mackerel (9%) during 1993-2003 (Figure 38; Appendix F, Table F.9). Many anglers sought no particular species (23%).

EEZ party-boat anglers primarily sought red snapper (26%), king mackerel (15%), or a combination of red snapper and king mackerel (17%) during 1993-2003 (Figure 38; Appendix G, Table G.9). Many anglers sought no particular species (29%).

### Angler Trip Satisfaction

Mean trip satisfaction responses among coastwide bay and pass, TTS, and EEZ private-boat and party-boat anglers trended slightly upward from 1987-88 to 2002-03 (Figures 39-40). For coastwide bay and pass private-boat and party-boat anglers, mean trip satisfaction responses reached all-time highs of 5.8 and 8.1, respectively, in 2002-03 (Appendix B, Table B.10; Appendix C, Table C.10). For coastwide TTS private-boat and party-boat anglers, mean trip satisfaction responses in 2002-03 were 6.1 and 8.6, respectively (Appendix D, Table D.10; Appendix E, Table E.10). For coastwide EEZ private-boat and party-boat anglers, mean trip satisfaction responses in 2002-03 were 6.4 and 9.0, respectively (Appendix F, Table F.10; Appendix G, Table G.10).

### Bay and Pass Private-boat Trips Lasting More Than 12 Hours

Coastwide bay and pass private-boat anglers on trips lasting more than 12 h annually expended an average of 222 thousand man-h to land an average of 44 thousand fishes during 1993-2003 (Figure 41; Appendix H, Tables H.2, H.3). The majority of bay and pass private-boat fishing pressure (65%) and landings (63%) from trips lasting more than 12 h occurred in the upper Laguna Madre bay system (Figure 42).

Spotted seatrout (53%), red drum (16%), black drum (10%), and southern flounder (6%) were the most landed species by bay and pass private-boat anglers on trips lasting more than 12 h during 1993-2003 (Figure 43). Coastwide catch rates for spotted seatrout and red drum in 2002-03 were 0.08 and 0.04 fish/man-h, respectively (Appendix H, Table H.4).

During 1993-2003, the majority (51%) of annual coastwide bay and pass private-boat anglers on trips lasting more than 12 h resided in coastal counties adjacent to the bay system fished, but a large proportion (35%) resided in non-coastal counties (Figure 44; Appendix H, Table H.5). Residential origin of anglers among bay systems is presented in Figure 45.

## Supporting Information

Several sources of supporting information were assembled to aid in interpretation of study results.

Sales of recreational fishing licenses in Texas increased steadily from about 0.5 million in 1956 to a high of about 2.0 million in 1983, then generally decreased to about 1.7 million in 2003 (Figure 46; Appendix I, Table I.1).

Sales of saltwater sportfishing stamps in Texas increased from about 0.4 million in 1986 to about 0.8 million in 2003 (Figure 46; Appendix I, Table I.2).

Texas boat registrations increased from about 0.3 million in 1969 to about 0.6 million in 1981, then remained at that level through 2003 (Figure 46; Appendix I, Table I.2).

The first regulations affecting harvest of saltwater fishes by sport anglers in Texas were established in 1955 for flounder, red drum, and spotted seatrout in Cameron, Kenedy, and Willacy Counties (Appendix I, Table I.3). In 2003, the sport harvest of 22 species or species groups was regulated.

Literature sources related to the survey of marine sport fishing in Texas are listed in Appendix J.

Literature sources related to significant environmental events along the Texas coast are listed in Appendix K.

## DISCUSSION

Chapter 66 (Fish), Subchapter C (Saltwater Fishing), Section 66.217 (Finfish Research) of the Texas Parks and Wildlife Code directs the Texas Parks and Wildlife Department (TPWD) to conduct continuous research and study of the supply of various species of finfish, including red drum and spotted seatrout (State of Texas 2004). The Texas Marine Sport-Harvest Monitoring Program, subject of this report, and the Texas Marine Resource Monitoring Program (Martinez-Andrade et al. 2005) were designed to comply with this directive. Fishery-dependent and fishery-independent data collected through these programs have been used by the Coastal Fisheries Division of TPWD to manage the coastal fisheries of Texas. Since 1977, size, bag, and/or possession limits were established and/or modified for 23 fish species; game fish status was extended to 15 species; non-commercial status was extended to 10 species; use of trotlines to take fish was restricted; and use of nets and seines to take fish was restricted, then banned (except for cast nets, dip nets, and minnow seines).

When the sport-harvest monitoring program was initiated (1974-76), boat ramps, wade and bank areas, and lighted commercial piers were surveyed. Budget constraints and difficulties associated with surveying wade and bank areas and lighted commercial piers led to a focus on

boat-access sites in subsequent years. The sport-boat portion of the fishery proved more amiable to a long-term monitoring program for assessment of trends in finfish landings.

In addition to its primary purpose, the survey has served as a useful instrument for collection of other fisheries-related data. A social and economic questionnaire was administered to anglers during 1976-78 in cooperation with another state agency to estimate the economic impacts of sport fishing on local and state economies (Texas Department of Water Resources 1980a, 1980b, 1981a, 1981b, 1981c, 1983). Data was collected during 1979-81 to determine whether an enacted size-limit regulation reduced the number of small spotted seatrout retained by anglers (Meador and Green 1986). Private-boat anglers were queried during 1982-83 to determine their short-term fishing avidity (TPWD unpublished data). An ongoing effort to estimate the amount and source of live and dead bait shrimp used by anglers was initiated in 1983 (Osborn and Spiller 1991). Anglers were asked during 1984-87 whether they had fished an oil or gas platform during a portion of their trips (TPWD unpublished data). A social and economic questionnaire with both pre-trip and post-trip questions was administered to anglers during 1987-91 (Green et al. 1991a, 1991b, 1991c). Two elements of this questionnaire, species sought and trip satisfaction, were retained for ongoing application. During the 1993 high-use season, private-boat anglers were asked to recall the species and number of fish they had caught but not retained in an effort to characterize and estimate bycatch (Campbell and Choucair 1995). Anglers were queried to determine the amount and source of live and dead mullet (Mugil sp.) used as bait during 1992-95 and the amount and source of live and dead Atlantic croaker used as bait during 1995-96 and 2002-04 (TPWD unpublished data). Angler compliance with an enacted trophy-tag regulation for retention of over-size red drum was examined during 1994-97 (TPWD unpublished data). Anglers using live or dead fish for bait were queried during 1995-96 to determine types of fish used for bait (TPWD unpublished data). During 1995-96, information was collected from angling parties with trip lengths more than 12 h for adjustment of such trip lengths to obtain comparability with daily trips of 12 h or less (Spiller et al. 2000). In cooperation with the Corpus Christi Bay National Estuary Program, a sportfishing valuation questionnaire was administered to anglers in Aransas, Corpus Christi, and upper Laguna Madre bay systems during 1996-97 (Wellman and Noble 1997). During 2000-01 as part of a seagrass conservation initiative, mailing addresses were collected from interviewed anglers who had fished specific areas in the Aransas and upper Laguna Madre Bay systems for a follow-up mail survey. A portion of the party-boat interview data collected during 2001-03 was shared with the Gulf States Marine Fisheries Commission to aid in the evaluation of an alternative method for estimating party-boat fishing pressure and landings.

As funds and personnel become available, future efforts should be made to prepare reports on collected data in a more timely manner; improve estimates of party-boat fishing effort and landings, especially for the gulf; and collect additional social and economic data.

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